Aalto University
School of Economics

The role of investment appraisal methods and versatility of expertise in energy efficiency investment decisions

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Department of Accounting
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Abstract
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THE ROLE OF INVESTMENT APPRAISAL METHODS AND VERSATILITY OF EXPERTISE IN ENERGY EFFICIENCY INVESTMENT DECISIONS

PURPOSE OF THE STUDY

This study examines the decision-making in Finnish industrial companies with regard to energy efficiency investments. It aims to identify factors that hinder the implementation of energy efficiency investments in industrial sector. The focus is especially on the investment appraisal methods and the investment process participants influencing the investment decision-making. The results of this study may act as a guide for companies in improving their investment processes to support more equal and comprehensive evaluation among different kind of investments.

DATA

The research was executed in two phases, firstly, by doing a survey questionnaire and secondly, by conducting follow-up interviews based on the findings received from the survey. Altogether 345 energy efficiency representatives in the Finnish industrial companies received the questionnaire and 107 replied with filled online form resulting in a response rate of 31 %. After statistical analysis, seven people were interviewed in order to gain broader understanding of the findings.

RESULTS

The findings of this study indicate that the main reason why investment opportunities become rejected is the investment's inability to match the financial profitability criteria set for evaluating capital expenditure. The most commonly used financial investment appraisal method for operational and energy efficiency investments is the payback period method followed by the internal rate of return and net present value methods. Strategic investment appraisal methods are still used infrequently.

Results indicate that companies that are using sophisticated financial investment appraisal methods and more specifically IRR when evaluating energy efficiency investments go on to implement more energy efficiency investments than other Finnish industrial companies. This study also suggests that having a financial expert involved in the investment process already from the planning stage increases the likelihood that energy efficiency investment will be approved in the decision-making stage. However, Finnish industrial companies' investment project teams are usually not very versatile and consist mainly of technical experts.

KEYWORDS

Energy efficiency, energy efficiency investment, investment appraisal, investment process participants.

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20. tammikuuta 2012

INVESTOINTIEN ARVIOINTIMENETELMIEN JA MONIPUOLISEN ASIANTUNTIJATIIMIN ROOLI ENERGIATEHOKKUUSINVESTOINTIPÄÄTÖKSISSÄ

TUTKIELMAN TAVOITTEET

Tutkimuksen tavoitteena oli selvittää mitkä investointiprosessiin liittyvät syyt vaikuttavat siihen, että energiatehokkuusinvestointeja toteutetaan Suomen teollisuusyrityksissä harvoin. Mielenkiinnon kohteina olivat erityisesti yritysten käyttämät investointien arviointimenetelmät sekä investointiprosessissa vaikuttavien henkilöiden asiantuntijuus ja tausta. Tutkimuksen tuloksia on mahdollista hyödyntää yritysten investointikäytäntöjen kehittämisessä ottamaan huomioon paremmin erilaisten investointien arviointitarpeita.

LÄHDEAINEISTO

Tutkimus toteutettiin kahdessa vaiheessa, ensin toteutettiin Suomen teollisuusyritykset kattava kyselytutkimus koskien yritysten investointikäyttäytymistä erityisesti energiatehokkuusinvestointien näkökulmasta. Tilastollisen analyysin jälkeen mielenkiintoisimpien merkitsevien tulosten ymmärrystä pyrittiin laajentamaan tekemällä jatkohaastatteluja puhelimitse. Kyselytutkimus lähetettiin 345:lle Suomessa toimivan teollisuusyrityksen energiatehokkuusvastaavalle ja vastausprosentiksi saatiin 31 %. Jatkohaastattelut tehtiin seitsemän yrityksen joko investointipäällikön tai energiatehokkuusvastaavan kanssa.

TULOKSET

Tutkimuksen mukaan yritysten ensisijainen kriteeri investointien hylkäämiselle on se, etteivät ne vaikuta taloudellisten arviointimenetelmien mukaan kannattavilta. Suomen teollisuusyrityksissä selkeästi eniten käytetty investointien arviointimenetelmä on takaisinmaksuajan menetelmä. Tulokset indikoivat, että yritykset, jotka käyttävät sofistikoituneempia menetelmiä, erityisesti sisäisen korkokannan menetelmää, arvioidessaan energiatehokkuusinvestointien kannattavuutta, tekevät enemmän energiatehokkuusinvestointeja kuin muut toimialan yritykset. Lisäksi tutkimus osoittaa, että yrityksille, joiden investointimahdollisuuden suunnittelussa on jo mukana taloudellinen asiantuntija, on energiatehokkuusinvestointien toteuttaminen todennäköisempää.

AVAINSANAT

Energiatehokkuus, energiatehokkuusinvestointi, investointien arviointi, investointiprosessin asiantuntijat.

FOREWORD

This study is part of a broader Tekes (the Finnish Funding Agency for Technology and Innovation) associated study about *Energy efficiency from a business management perspective*. It was done in cooperation with Aalto University School of Economics and School of Engineering and Motiva Oy. Motiva is an expert company promoting efficient and sustainable use of energy and materials.

I want to express my appreciation for Hille Hyytiä and Pyry Penttinen from Motiva for pleasant cooperation. In addition, I want to give warm thanks to my supervisor Professor Teemu Malmi and my instructors Tuija Virtanen, D. Sc. (Econ.) and Mari Tuomaala, D. Sc. (Tech.) for giving me valuable support and guidance throughout the research process. I also want to thank researcher Antti Lehtoranta from Aalto University for providing valuable statistical support and viewpoints during the research project. Finally, I want to thank my friends and family for their interest and support.

Helsinki, 20. January 2012

Anne Halttunen

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1. Introduction

Energy efficient manufacturing processes can create important cost savings, future investment opportunities and increase company's competitive advantage. In the world where the environmental concerns are acknowledged, they are also one way for companies to improve their sustainability and thus their reputation. Several research studies have, however, claimed that in reality many cost-efficient, profitable energy efficiency investments are rejected in industrial companies in favor of other investment opportunities (Jaffe & Stavins, 1994; Pye & McKane, 2000; Härus, 2009; Jackson, 2010). A variety of factors have been advanced to explain this phenomenon, also understood as energy paradox (Shama, 1983; Jaffe & Stavins, 1994). Previously discovered probable causes include principal-agent issues that result in short-term managerial decisions, capital rationing, the irreversible nature of energy efficiency investments, bounded rationality, lack of information on equipment performance, energy price uncertainty and transactions costs, as well as the lack of appropriate investment evaluation methods (DeCanio, 1993; Sanstad and Howarth, 1994; Brown et al., 2001; Schleich, 2009; Ansar and Sparks, 2009; Härus, 2009; Jackson, 2010).

Energy efficiency investment's non-energy related benefits have often been disregarded in investment analysis even though they may even exceed the value of energy savings and often have valuable strategic implications (Pye & McKane, 2000; Härus, 2009; Jackson, 2010). The dismissal of these investments may be caused by the fact that companies tend to rely heavily on financial analyses, regardless of whether the investment project is strategic or nonstrategic in nature, thus failing to treat different kind of investment opportunities equally (e.g. Abdel-Kader and Dugdale, 1998; Alkaraan & Northcott, 2006; Härus, 2009; Carr et al, 2010; Tuomaala & Virtanen, 2011).

This study explores the drivers of energy efficiency investment decisions and for more specifically, aims to identify factors that hinder the implementation of energy efficiency investments in Finnish industrial sector. The focus is especially on the investment appraisal methods and the investment process participants influencing the investment decision-making, since previous research has given reason to assume that these could be some of the causes of the energy paradox (Jaffe & Stavins, 1994; Härus, 2009; Tuomaala & Virtanen, 2011). The investment process description presented in section 2.3 and the found results may act as a guide for companies in improving their investment processes to support more equal and comprehensive evaluation among different kind of investments.

2. Energy efficiency investment decisions

2.1 Energy efficiency investments

Capital investments are generally divided into operational investments and strategic investments (e.g. Pinches, 1982; Alkaraan & Northcott, 2006). Strategic investments are described by having a significant effect on company as a whole and its long term performance (Ghemawat, 1999; Butler et al., 1993). Strategic investments may sometimes involve high levels of risk and produce hard-to-quantify or intangible outcomes (Alkaraan & Northcott, 2006). In general, research had depict that energy efficiency investments include aspects that can be considered strategically relevant, however, not necessarily very attractive from the financial point of view (Awerbuch, 2000). Nevertheless, they usually can be associated as either strategic investments or pure operative investments.

The importance of energy efficiency is well acknowledged especially in the social and political level (e.g. Jaffe & Stavins, 1994; Pye et al., 2000; Tonn & Peretz, 2007; Thollander et al, 2007; 2010). Energy efficiency is a term that covers a broad range of technologies, processes, and even changes in behavior (Tonn & Peretz, 2007). Energy efficiency is traditionally defined as ‘‘a ratio between an output of performance, service, goods or energy, and an input of energy’’ (EU, 2006). Energy efficiency plan (2011) clarifies that technically, 'energy efficiency' means using less energy inputs while maintaining an equivalent level of economic activity or service. In addition, energy efficiency can also mean the increases in production when energy consumption are kept to same or when amount of production increases more than does the energy consumption (Tuomaala, 2007). However, while an investment in manufacturing capacity might simultaneously improve energy efficiency, it cannot be justified to categorize all such investments as energy efficiency investments (Härus, 2009).

According to European Commission (2011), energy efficiency is the key for reducing CO_2 emissions and preventing climate change. The importance of energy efficiency is also linked to commercial and industrial competitiveness. The direct cost of the inability to use energy efficiently amounts to more than 100 billion euros annually by 2020 (European Commission, 2011). In Finland, industry is responsible for over 50 % of total energy consumption and 80 % of this energy is used in the process industry (EK, 2011).

Energy efficiency investments are part of a traditional firm level capital budgeting process, especially in the case of industrial enterprises (Jackson, 2010). However, how they are perceived and treated in industrial companies' capital budgeting processes contain still major discrepancies. Earlier it was assumed that environmental protection and financial competitiveness will not fit into profitable equation. Today, however, it is widely acknowledged that the environment can be protected by using resources more efficiently: energy efficiency and pollution prevention are just two ways of increasing productivity. According to Pye & McKane (2000) potential benefits beyond energy savings, in a company's point of view, may include:

- Increased productivity
- Reduced costs of environmental compliance
- Reduced production costs (including labor, operations and maintenance, raw materials)
- Reduced waste disposal costs
- Improved product quality (reduced scrap, rework costs, improved customer satisfaction)

Generally the productivity gains are seen to be the ones to motivate industry to take action (Pye & McKane, 2000). Significant changes in companies' production technology and production processes tend to occur very occasionally and are mainly driven by decisions related to technology changes, market demand and other longer-term strategic issues (Elliott et al., 2008). These can be integrated into companies' practices and processes by making profitable energy efficiency investments. In addition to above mentioned benefits, energy efficiency has also been widely promoted as a risk management tool (Russell, 2005; Naumoff and Shipley, 2007); reducing energy costs reduces exposure to energy price volatility.

Despite the wide academic literature on energy efficiency, the concept of energy efficiency investment has not yet been unambiguously defined. However, there have been strive to do so (e.g. Pirttilä & Sandström, 1995; Pye & McKane, 2000; Härus, 2009) and on the broadest level, the definition would include all investments that improve energy efficiency. Härus (2009) narrows this definition by dividing energy efficiency investments to pure energy efficiency investments or hybrids, pure capacity investments with significant energy efficiency benefits. Common problem in practice is that companies tend to distinct investments to different categories even though the concepts are seemingly intertwined. Pirttilä & Sandström (1995) aim to take also into account investments' strategic implications. Growth options are one of the relevant strategic implications in capital investments. They can often open doors to other future investment opportunities and thus

create competitive advantage for the company or prevent company to drop out of the competition (Shapiro, 2005: 100).

2.2 Investment appraisal methods

Investment appraisal methods have gained much attention in capital budgeting literature, however, only few studies have focused on energy efficiency investment appraisal methods. Every capital investment consumes resources. Inadequate evaluation and decision tools increase the possibility that scarce resources are allocated to areas that do not provide optimal returns above the cost of capital, destroying the company value (e.g. Copeland & Tufano, 2004; Shapiro, 2005). It also works vice versa: an appraisal system that fails to apply resources to profitable projects may results as a potential loss of competitive position (Porter, 1985).

Investments can be evaluated with traditional payback period (PB) or more sophisticated discounted cash flow (DCF) methods: net present value (NPV), internal rate of return (IRR), profitability index (PI) (e.g. Haka et al., 1985; Chen and Clark, 1994; Lefley, 1994; Pike, 1996; Graham and Harvey, 2001; Ryan and Ryan, 2002; Sandahl and Sjogren, 2003; Berkovitch and Israel, 2004; Marino and Matusaka, 2005). In addition, there are more strategic investment evaluation methods: technology roadmapping, strategic cost management and value chain analysis (e.g. Shapiro, 2005; Alkaraan & Northcott, 2006; Hopper et al., 2007; Tuomaala & Virtanen, 2011). These methods are applying cost analysis concepts as well as taking into account the strategic aspects and the context for the investment opportunity (Shank, 1996). Value chain analysis is advanced as a useful tool to help businesses identify their strategically important value-creating activities and develop appropriate competitive strategies (Shank and Govindarajan, 1992; Hoque, 2001). Technology roadmapping, on the other hand, is described as "a process that contributes to the definition of technology strategy by displaying the interaction between products and technologies over time" (Groenveld, 1997, p. 48) by using charts and graphs to reveal the links between technology and business needs (Alkaraan & Northcott, 2006).

According to previous research, clearly the most common investment evaluation methods are the payback period, net present value and the internal rate of return (e.g. Ross, 1986; Pike, 1988; 1996; Carr and Tomkins, 1996, 1998; Arnold and Hatzopoulos, 2000; Graham and Harvey, 2001; Sandahl and Sjögren, 2003; Tuomaala & Virtanen, 2011). Simple payback rule-of-thumb decision-rules are common with energy efficiency investments. Companies feel that the complexity of measuring

energy efficiency investment's future savings makes the payback period an adequate method for financial investment evaluation (Jackson, 2010).

Ross's (1986) study observed that only a limited number of profitable energy efficiency investments passed the payback screening process. A study by Anderson and Newell (2002) of 9000 small to medium sized manufacturing firms found an average payback requirement of 1.29 years, which seems very short considering the nature of energy efficiency investments. If PB estimate is a necessary condition for a project to be considered further in an investment evaluation process, is very likely that the payback criterion would set to be one of the major causes why investment choices are biased towards ''sure bet'' investments. Hence companies will be rejecting potential, profitable energy efficiency investments, the profits of which capitalize usually in a longer term (Alkaraan & Northcott, 2006; Jackson, 2008; 2010; Tuomaala & Virtanen, 2011).

Product quality, fit with the business strategy and improved competitive position are amongst those factors identified as important influences on strategic investment decision-making (Pike et al., 1989; Pye et al., 2000). Yet, these hard-to-quantify benefits from strategic investments remain difficult to evaluate using conventional financial techniques, suggesting that strategic investment decision-making may require a different approach (e.g. Pike et al., 1989; Butler et al., 1991; Brookfield, 1995; Slagmulder et al., 1995; Pike, 1996; Van Cauwenbergh et al., 1996; Carr and Tomkins, 1996, 1998; Busby and Pitts, 1997; Covin et al., 2001; Ryan and Ryan, 2002; Dempsey, 2003; Alkaraan and Northcott, 2006). By adding strategic investment appraisal methods to the investment process and using them in conjunction with the financial considerations is claimed to be the key for improving the quality of the investment decisions (Slagmulder et al., 1995; Lefley, 1996; Putterill et al., 1996; Shank, 1996; Adler, 2000; Tuomaala & Virtanen, 2011). This could be one of the answers for energy paradox as well (Härus, 2009). Nevertheless, companies tend to use them very rarely (Milis and Mercken, 2003; Lyons et al., 2003; Alkaraan & Northcott, 2006).

In conclusion, the complex nature of energy efficiency investments makes them difficult to evaluate with the traditional investment evaluation methods and thus seems that they may be unfairly rejected compared to traditional operational investments. More comprehensive view of the energy efficiency investment's financial return and strategic compatibility could possibly be attained with more sophisticated and strategic investment appraisal methods, and thus more equal treatment among other kind of investment possibilities. Hence, it is intriguing to examine whether some investment appraisal methods are more common in the companies that implement energy efficiency

investments and if so, why would this causal relation exist. Following hypothesis are selected for further empirical study:

> H1. Companies that use more sophisticated financial investment appraisal methods implement more energy efficiency investments than companies using more conventional methods, such as the payback period.
>
> H2. Companies that use more strategic investment appraisal methods implement more energy efficiency investments than other companies in Finnish industrial sector.

2.3 Investment process and versatility of expertise

The selected investment appraisal methods signal the attitudes, goals and objectives of the company to the employees and other stakeholders involved in the company's investment decision process. They should be aligned with the company strategy and thus acknowledged also in the processes that guide performance towards these strategic goals. The need for tools that support the decision-making process in investment selection and evaluation has been addressed early on in the engineering and business world (Tziralis, 2009). However, the investment appraisal methods are only one aspect affecting the energy efficiency investment decisions. It has already been acknowledged in the capital budgeting literature's process view that the investment process consists of complex aspects in the organizational setting. The process view in investment theory concentrates on examining the organizational social processes, by which capital budgeting projects become identified, developed, justified and finally approved (Pirttilä & Sandström, 1995).

There are a variety of investment process descriptions that try to illustrate the process attributes and the decision-making process in general (e.g. Skinner, 1969; Hayes & Wheelwright, 1984; Pirttilä & Sandström, 1995; Drury, 1996: 385; Diesen, 1998; Cziner et al., 2005; Bhimani et al., 2008; Tziralis et al., 2009) However, no other study was found to have created an investment process description especially for the energy efficiency point of view. Two different viewpoints could, however, be highlighted from the previous research discussion to support the creation: (1) technical and (2) financial perspective. The former have the main focus in design and planning, whereas the latter focus merely on the parts that can be discussed with financial constraints. These two viewpoints needed synthesis and top-up so that the comprehensive investment process description (Figure 1.) was able to be formed especially for the industrial companies' needs. Investment process is all but a separate process in company's operations. The successful exploitation of the model

requires company to adjust the model to its individual needs by forming a guiding investment process description for its employees.

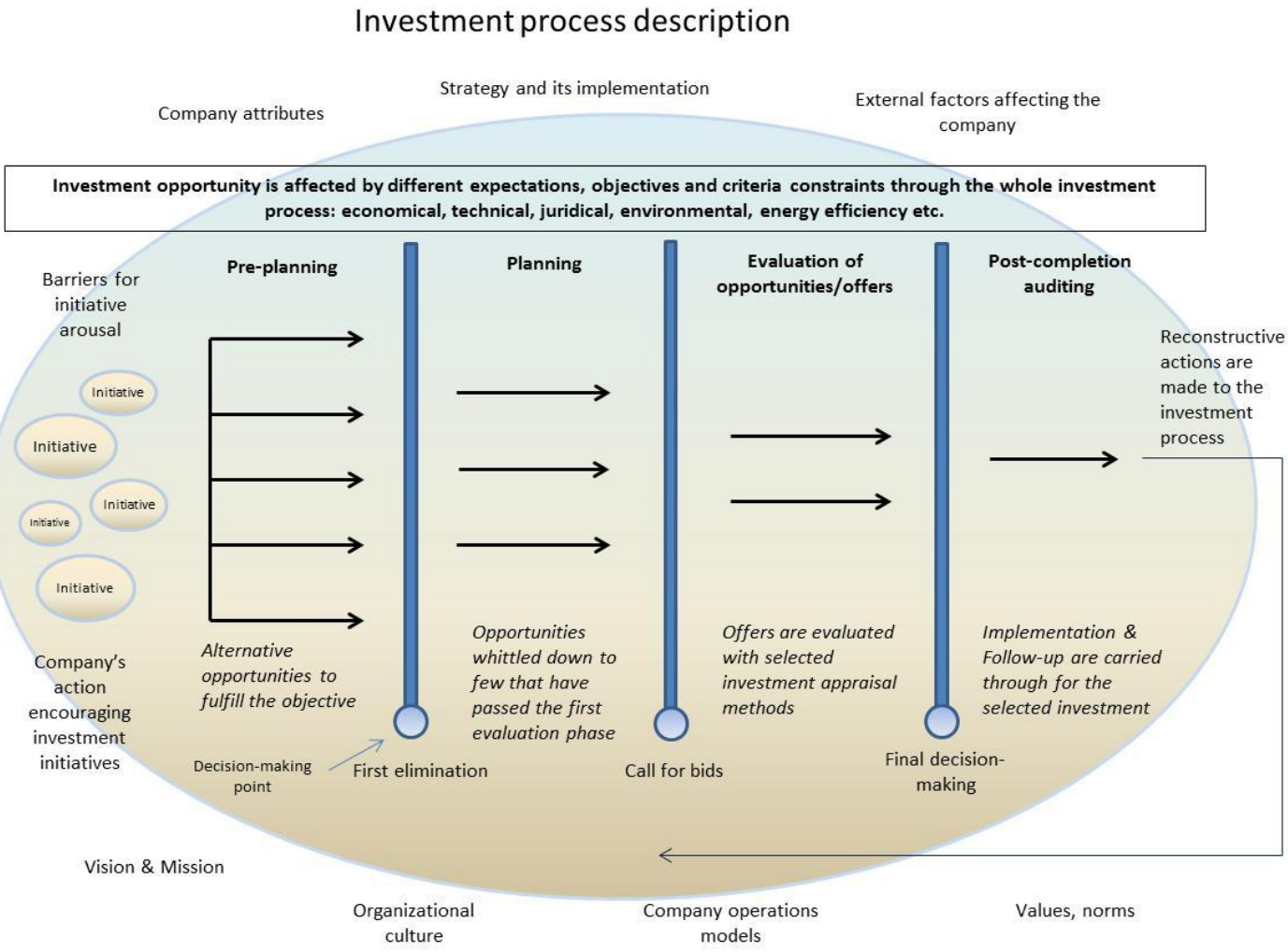

Figure 1. Investment process description

Various internal (e.g. the organizational culture, norms and patterns) and external factors (e.g. industry related risks) have an influence on the decisions and the whole process. Managers need to clearly focus and prioritize their goals for each investment project so that the employees involved can adopt the appropriate practices that will facilitate their goal achievement through the whole investment process (Bower, 1970; Scott-Young & Samson, 2008). In an organizational setting, the alternative investment opportunities are commonly available and need to be ranked according to company's objectives. In the final decision-making stage, economic arguments are usually seen to be the most effective in justifying the selection (Lumijärvi, 1991). In the case of energy efficiency investments, other relevant decision-making criteria might also include for example technical

arguments (material efficiency, process reliability and quality), environmental arguments, energy efficiency arguments, safety or risk attributes.

Investment process may involve a large number of various parties in different fields of expertise. For example in the case of an energy efficiency investment process all the way from planning to post-completion auditing can involve engineers, financial experts, managers, energy efficiency responsible, board members or other parties with some specific interests and attitudes towards the investment. It is reasonable to assume that usually stakeholders participating in an investment decision-making process aim at selecting the most suitable investment for the company or providing the best feasible solution for a particular project. However, the understanding of the 'best feasible' differs among stakeholders (Tziralis et al., 2009).

In addition to their background, politics between decision makers or human errors such as miscalculation may influence the whole investment process and thus make the decision more subjective than initially thought (Lumijärvi, 1991). Consequently, Bower (1970) observed that the investment projects pass through different hierarchical phases and capital investment decisions can in fact be made already by managers at various levels, not only by the top management of the organization in the decision-making stage. Process participants can also differ according to their overall commitment to the investment (Bower, 1970). These behavioral factors are subject to biases that can distort the optimal investment process. It is already acknowledged that people's attitudes towards new technology and energy efficiency as well as status quo bias[1], escalation of commitment[2] and heuristics[3] can affect the energy efficiency decision-making (Yim Kwong Cheng, 2010; Masini & Menichetti, 2012). In subjectivity account, energy efficiency investments may especially face unwanted skepticism when they are compared with the old 'well-proved' operative alternatives. Taking into account the call for objective and professional evaluation of energy efficiency investments, following hypothesis are selected for further empirical study:

[1] The status quo bias is defined as the preference to maintain the current state of affairs rather than forge a new route (Anderson, 2003)

[2] The irrational decision to allocate additional resources to a project that has encountered setbacks or losses and whose prospects of future returns are unfavorable (Fox and Hoffman, 2002)

[3] Heuristics are "mental" shortcuts people use commonly to help make decisions or form judgments, particularly when facing incomplete information or complex problems. (Yim Kwong Cheng, 2010)

H3: Companies that have more versatile team of expertise already in planning the energy efficiency investment opportunity, implement more energy efficiency investments than companies that do not have.

H4: Companies that have more versatile team of expertise in making the final investment decision, implement more energy efficiency investments than companies that do not have.

3. Research method

The research was executed in two phases, firstly, by doing a survey questionnaire (Appendix 3) and secondly, by doing follow-up interviews based on the findings received from the survey (Appendix 4). The survey questionnaire was conducted in cooperation with Motiva[4]. The survey was sent by email to all Finnish industrial companies that have a designated person responsible for energy efficiency issues in Motiva's database.

The sampling, Finnish industrial companies, was selected based on the energy efficiency intensive nature of their business. The sample included companies with a variety of turnovers, personnel sizes, business focus areas and amount of energy efficiency investments they had previously made. Altogether 345 energy efficiency responsible received the questionnaire and 107 replied with filled online form resulting in a response rate of 31 %. 95, 2 % of the respondents were actively involved in energy efficiency investment processes. Most of the respondents had a technical background (89, 4 %), while the other were persons with a financial background (5 %) or some other background, such as an environmental related one. Some respondents had left a few questions unanswered, thus all questions did not provide 107 observations. However, because the amount of the missing observations in these questions was relatively low (< 5 %), processing the missing responses was seen irrelevant (Appendix 2).

Questions were created based on previous research of capital investment practices, the created investment process description (Figure 1.) as well as expert discussions with researchers from Aalto University and Motiva. Most questions required respondents to assign a score on a five-point Likert scale. As a regression model for ordinal dependent variables in Likert scale, ordered logit

[4] Motiva Oy is an expert company promoting efficient and sustainable use of energy and materials.

regressions were seen to be the most appropriate, as well as the mfx[5] command for examining the marginal effects of the most intriguing ordered logit findings.

The dependent variable is an indicator for the partial amount of energy efficiency investments from company's total investments (*Energy ef. inv*) (Patterns 1 to 4). The data for the dependent variable was collected in a survey questionnaire by asking the amount of company's total investments in 2009 and the share (%) of energy efficiency investments out of those total investments. In order to avoid different interpretations, a guiding definition of 'energy efficiency investment' was provided in the questionnaire as follows:

> *Energy efficiency investment is an investment that is either mainly or partly implemented in order to achieve energy efficiency gains, where the energy efficiency gain can be identified.*

For the first and second hypotheses, following variables were selected for examination of basic financial evaluation methods: payback period (*PB*), net present value (*NPV),* internal rate of return (*IRR*), profitability index (*PI*) and non-financial, strategic methods: Technology roadmapping (*TR*) and Value chain / Strategic cost management analysis (*VC/SCM*). These methods were selected because they are found to be the most commonly used investment appraisal techniques according to management accounting research. In order to found correlations more comprehensively, three new variables were formed from these as follows: payback period was kept alone as a simplistic method (*PB*), whereas NPV, IRR and PI formed a variable of sophisticated investment appraisal methods (*Soph.*) and Technology roadmapping and Value chain/Strategic cost management analysis formed a variable strategic investment appraisal methods[6] (*Strat.*) keeping the dependent variable the same.

H1: $$Energy\ ef.inv = \alpha + \beta_1 PB + \beta_2 NPV + \beta_3 IRR + \beta_4 TR + \beta_5 VC/SCM + \varepsilon \quad (1)$$

H2: $$Energy\ ef.inv = \alpha + \delta_1 PB + \delta_2 Soph. + \delta_3 Strat. + \varepsilon \quad (2)$$

[5] Mfx is a command used in statistical program Stata for estimating regression variables' marginal effects.

[6] The Balanced Scorecard was initially one of the selected strategic investment appraisal methods (Alkaraan & Northcott, 2006; Hopper et al., 2007), but since a misunderstanding of the concept in investment evaluation purposes was discovered among the interviewed, the reliability of the entire model was increased by leaving the BSC out of the study.

Following variables were selected to answer for the third and fourth hypothesis: technical expert (*Tech.exp.*), financial expert (e.g. CFO) (*Fin.exp.*), energy efficiency responsible (*En.ef.resp.*), management group (*MG*) where dependent variable is the relative amount that company implements energy efficiency investments (*Energy ef. inv*)) (Pattern 3 and 4). Investment process may involve a much larger number of various parties from different fields of expertise, but these were analyzed to be potentially involved in the energy efficiency investment decisions and have influence on them.

H3: $$Energy\ ef.inv = \alpha + \beta_1 Tech.exp. + \beta_2 Fin.exp. + \beta_3 En.ef.resp. + \beta_4 MG + \varepsilon \quad (3)$$

H4: $$Energy\ ef.inv = \alpha + \beta_1 Tech.exp. + \beta_2 Fin.exp. + \beta_3 En.ef.resp. + \beta_4 MG + \varepsilon \quad (4)$$

The data consists of very different kind of businesses, although they all belong to Finnish industrial sector. There are large and small companies, big and small investors and heavy and not so heavy energy consumers. Companies' turnovers, personnel sizes and many profitability measures were collected to increase the robustness of the regressions. However, it was soon noticed that in order to include those variables into regressions, the industry and the nature of the company's business would have had to be taken into account. Hence, the possibility to investigate whether there appears variance amongst industries in their propensity to make energy efficiency investments was considered. This would have been conducted by including an industry –dummy into the regression equation, however given the current sample size, this proved to be problematic. Dividing a sample of 107 companies into industries would have resulted in the dilution of regression results. A research questionnaire, with insignificant amount of responses, serves limited purpose to be divided into industries and is recommended to be examined with greater amount of samples in further studies.

4. Survey and interview findings

According to the survey, the primary reasons for energy efficiency investment implementation have been *Replacements for the old machinery* (37 %)[7] and *Attempt to save costs* (37 %). This result is consistent with the energy efficiency study made by Pye & McKane (2000), which depicted that generally the productivity gains are the ones seen to motivate industry to take action.

[7] Maximum of 100 %.

Respondents were also asked to specify why they think that their company has rejected energy efficiency investment opportunities in the past. *Energy efficiency investment didn't seem profitable according to calculations*, was identified by 65,3 %[8] of the respondents as the most significant reason for rejections. *Bad macroeconomic situation* (52,5 %) and *Other profitable investment opportunities bypassed the energy efficiency investments* (51,5 %) followed. These survey results suggest that the investment evaluation, and hence the investment appraisal methods that the company uses, would have a significant influence on the rejections.

[8] It was possible to select more than one reason for rejection.

Table 1. Descriptive statistics of the variables. The sample includes survey questionnaire responses from 107 Finnish industrial companies related to their energy efficiency investment decision making. Dependent variable is an indicator for the partial amount of energy efficiency investments from company's total investments. Dependent variable is a likert scale measure (4: over 10 %, 3: 5,1 - 10 %, 2: 1,1 - 5 %, 1: 0,1 - 1 % and 0: 0 % of total investments) and independent variables are dummy variables (1: Yes, 0: No). Mean indicates where the average response places between the likert scale or dummy variable measures.

	Obs	Mean	Std. Dev.
Dependent variable			
Energy efficiency investments implemented in 2009 (%)	107	2.276	1.040
Variable			
Involved in the planning stage			
Technical expert	104	0.827	
Financial expert (e.g. CFO)	104	0.346	
Energy efficiency responsible	104	0.548	
Management group	104	0.519	
Involved in the final decision making stage			
Technical expert	107	0.740	
Financial expert (e.g. CFO)	107	0.365	
Energy efficiency responsible	107	0.442	
Management group	107	0.740	
Company using following methods in evaluating energy efficiency investments			
Payback period (PB)	107	0.935	
Net present value (NPV)	107	0.290	
Internal rate of return (IRR)	107	0.393	
Profitability Index (PI)	107	0.103	
Value chain/Strategic cost management analysis	107	0.206	
Technology roadmapping	107	0.364	
Sophisticated appraisal methods	107	0.481	
Strategic appraisal methods	107	0.395	

4.1 Energy efficiency investment appraisal methods

Respondents were asked to evaluate the importance of certain investment evaluation criteria in investment decision-making in their company based on their individual experience (Table 2). The subjectivity of the question was allowed, because the criteria that are made explicit in the company are not always the ones that are actually obeyed. Table 2 presents the survey results on the scale of

criteria's importance. *Financial criteria* (85,6 %) were prioritized as the most important, which is in line with previous studies (e.g. Lumijärvi, 1991).

Table 2. Question concerning the importance of the evaluation criteria. 1st being the most important criteria whether to accept or reject an investment opportunity and so forth. (Appendix 3.)

Based on your experience, evaluate the importance of the below mentioned criteria in investment decision making in the company you are working for.

Respondents: 107

	1st	2nd	3rd	4th	I don't know
Financial criteria	**85.6 %** 89	**13.5 %** 14	**1 %** 1	**0 %** 0	**0 %** 0
Material efficiency	**21.2 %** 22	**52.9 %** 55	**25 %** 26	**0 %** 0	**1 %** 1
Process reliability	**60.6 %** 63	**34.6 %** 36	**4.8 %** 5	**0 %** 0	**0 %** 0
Process quality	**58.7 %** 61	**37.5 %** 39	**2.9 %** 3	**1 %** 1	**0 %** 0
Environmental criteria	**20.2 %** 21	**47.1 %** 49	**29.8 %** 31	**2.9 %** 3	**0 %** 0
Energy efficiency criteria	**22.1 %** 23	**50 %** 52	**26.9 %** 28	**1 %** 1	**0 %** 0
Safety criteria	**64.1 %** 66	**29.1 %** 30	**6.8 %** 7	**0 %** 0	**0 %** 0
Reliability	**60.6 %** 63	**36.5 %** 38	**2.9 %** 3	**0 %** 0	**0 %** 0
Technical risk	**35 %** 36	**49.5 %** 51	**13.6 %** 14	**0 %** 0	**1.9 %** 2

In addition to the criteria, people were also asked whether they think that energy efficiency investments are seen to be a significant strategic competitive factor for the company. Only 36,2 % of the Finnish industrial companies agreed with the question, however, additional statistical analysis showed significant result (+36 %; z = 2,18; 0.05 significance level) that these companies were relatively larger energy efficiency investors than the others.

From criteria to actual measures, Table 6 presents the survey results on the level of use of the most common financial investment appraisal methods in Finnish industrial companies. Survey results indicate that companies use primarily the payback period criterion when evaluating energy efficiency investments (93 %). The second most common method is IRR (39 %) following with NPV (29 %). This result is consistent with the recent studies introduced in section 2.2.

Table 3. Question concerning the use of investment appraisal methods for energy efficiency investment evaluation. (Appendix 3.)

We evaluate energy efficiency investment opportunities by using the following criteria **Respondents: 107**	**Total**
Payback period (PB)	**93 %**
Net present value (NPV)	**29 %**
Internal rate of return (IRR)	**39 %**
Profitability Index (PI)	**10 %**

It has been argued, that the payback period does not take into account either the time value of money or the cash flows beyond the payback criterion (Shapiro, 2005). Because of the possible strategic implications of energy efficiency investments, the use of PB can create severe boundaries for energy efficiency investments (Ross, 1986).

The role of the PB was examined in more detail in the follow-up interviews. The findings further magnify the power of the payback criterion as a requirement for an investment to go further. Some of the respondents wanted to clarify that they know that it is not an adequate measure to be used. However, they often find difficulties in measuring all the benefits and costs related to energy efficiency investments. Some of the respondents used discounted payback criterion in order to do more adequate evaluation.

Survey findings indicated that on average, the payback requirement is 3 years and it is about the same for energy efficiency investments and investments in general (e.g. operational). However, when we look at the companies' energy efficiency objectives, there can be seen to be a discrepancy. According to the survey, companies identified their future energy efficiency objectives on a time scale very different than the required criteria set for energy efficiency investments. Companies have set their energy efficiency objectives in 4 to 7 year scale[9] whereas the median for energy efficiency investments' payback criteria was only 1 to 2 years[10]. Companies tend to understand that energy

[9] Possible timescale alternatives to select were: (a) 1 year (b) 2 to 3 year (c) 4 to 7 year, (d) 8 or more (e) we do have, but they are not clearly specified (f) I don't know.

[10] Possible alternatives to select were: (a) 0 years, (b) 1-2 years, (c) 3-4 years, (d) 5-6 years, (e) 7-8 years, (f) over 8 years or (g) I don't know.

efficiency objectives are not acquired in the short-term but still the longer term investment opportunities are disregarded for not passing the payback criterion. One of the interviewed representing a company with relatively small energy efficiency investments, stated:

> *"We acknowledge that some energy efficiency investments have been rejected because of our strict payback criterion (3 years). That is the company policy at the moment that no investment with longer payback criteria is accepted. Company strategy is the cause, not our will."*

On the other hand, one of the respondents from a company that had implemented relatively large amounts of energy efficiency investments in 2009 revealed that the use of PB is more flexible in their company and also other factors are considered with different kinds of investments:

> *"We don't have a strict payback criterion for different kind of investments. We evaluate every investment individually. The payback criterion for profitability investments is 3 years, for development investments approximately between 3 to 5 years, and for strategic investments over 5 years."*

IRR emerged as the second most common financial investment appraisal method with 39 % of the companies using it for energy efficiency investment evaluation. The interviewees indicated that the IRR was seen to be very useful for ranking investments with similar kind of attributes. Interestingly, it seemed that companies that were using IRR, had also recognised that different investments needed to be evaluated separately. Companies that usually used PB and IRR together said that in larger investments, PB is not comprehensive and therefore IRR's as well as other aspects' of the energy efficiency investments roles increase. When it comes to using the IRR criterion, companies have various patterns: some of the interviewed said that they have strict required return for IRR, whereas some of them said that it always depends on the level of risk, whereas others said that they do not have strict policies for the required return level, not that they know of.

When the interviewees were asked to indicate why their company preferred the use of IRR to NPV or in general, why they have started using IRR and what they thought were its benefits, the most common answer was that someone from the management team or financial department had asked them to do so. In one occasion, an outside consultant had created an investment appraisal framework for them and it happened to include IRR among the other more sophisticated measures.

Financial considerations in investment decisions have usually received more attention than strategic ones. The reason behind the popularity of financial methods might be the fact that justifying

decisions with financial ratios, might make them seem more rational. However, many of the interviewees explained this phenomenon with convenience:

> *"Financial measures have a huge role in investment decision-making. The payback criterion is easy to understand."*

> *"The prices of steam, bark, fuel etc. can change several percentages, so it doesn't really matter which criterion we are using. – As such, we think it's useful to use simple calculations, because the biggest changes come from the inputs."*

As mentioned in section 2.2, previous studies have suggested that investments' strategic implications should be taken into account when evaluating investments. Table 4 summarizes the use of strategic investment appraisal methods in Finnish industrial companies. Technology roadmapping (36 %) is the most common strategic investment appraisal method used. Value chain or strategic cost management analysis are still exploited very rarely (21 %).

Table 4. Question concerning the use of investment appraisal methods for energy efficiency investment evaluation. (Appendix 3.)

We evaluate energy efficiency investment opportunities by using the following criteria **Respondents: 107**	**Total**
Value chain / Strategic cost management analysis	**21 %**
Technology roadmapping	**36 %**

As noted earlier, energy efficiency investments' hard-to-quantify benefits are found difficult to evaluate using conventional financial techniques, which could be solved by strategic evaluation methods (Butler et al., 1991; Van Cauwenbergh et al., 1996; Covin et al., 2001; Alkaraan and Northcott, 2006). By looking at the survey results, it seems that some of the companies have realised this and thus are using these methods in practice. According to the interviews, strategic benefits are not evaluated at all in companies implementing energy efficiency investments less than average. However, one of the companies had realised the benefits after the implementation of a small energy efficiency investment:

”Energy efficiency benefits became apparent at work. Work suddenly became easier and faster and we gained personnel cost savings. We did not estimate these kind of benefits to occur beforehand. Yet strategic benefits hadn’t been taken into consideration.”

Many of the companies that had mentioned the use of strategic methods, clarified that they are only using them when the investment is relatively big, millions of euros, as evidenced in this interview comment given by a person from a company with large energy efficiency investments:

”*Yes, we take also into account investment’s strategic benefits. When we are making a 20 million investment for condensation machinery, we have to do that. You cannot evaluate that with fixed prices or IRR.”*

All of the respondents that were from companies with relatively large energy efficiency investments indicate that the energy efficiency investments need to be evaluated more broadly in order to gain wider ground for the investment decision. The common trend seems to be that when the complexity and the amount of euros included in the investment increases, the used methods became more sophisticated. The follow-up interviews, despite the small number of conducted, gave evidence that more comprehensive evaluation would decrease the energy efficiency gap.

Quantitative analysis was executed in order to test the hypothesis. Table 5 shows the regressions (=models) made from the sample. Pseudo R^2 presents the reliability and significance of the model and it is interpreted simplisticly as “the smaller, the more reliable”. By dropping out some unreliable variables from the regression may increase the overall reliability of the model. Thus it is reasonable to test the hypothesis by making various models and compare their reliability. Nevertheless, also the number of the observations (N) have to be taken into account. When N decreases, the more unreliable the sample is. By taking into account R^2 and N, the Model 2 from the Table 5 was selected for more careful examination and where IRR gave significant results. Table 5.a presents the marginal effects for the studied phenomenons from the Model 2. When the real effects of the single significant variable to the dependent variable want to be observed in Likert scale sample, the marginal effects are in focus.

Table 5. This table reports ordered logit regressions coefficients and their z-values. The sample includes survey questionnaire responses from 107 Finnish industrial companies related to their energy efficiency investment decision making. Dependent variable is an indicator for the partial amount of energy efficiency investments from company's total investments. Dependent variable is a likert scale measure (4: over 10 %, 3: 5,1 - 10 %, 2: 1,1 - 5 %, 1: 0,1 - 1 % and 0: 0 % of total investments) and independent variables are dummy variables (1: Yes, 0: No). McFadden's R^2 is selected for to show the adjustment effect in Pseudo R^2.
*** = 0.01 significance level, ** = 0.05 significance level, * = 0.1 significance level

	Model 1	**Model 2**	**Model 3**
Payback period (PB)	2.50*	2.04	
	(1.71)	(1.55)	
Net present value (NPV)	-1.87**	-0.99	-0.58
	(-2.04)	(-1.49)	(-0.93)
Internal rate of return (IRR)	2.03**	2.06***	1.64***
	(2.37)	(3.16)	(2.73)
Profitability Index (PI)	-1.10	-0.57	
	(-1.23)	(-0.82)	
Value chain/Strategic cost management analysis	-0.32		
	(-0.43)		
Technology roadmapping	0.69		
	(0.74)		
N	42	76	75
Pseudo R^2	0.075	0.057	0.031

Table 5.a This table presents the marginal effects between the likert scale values of the original ordered logit regression for Model 2 (Table 5). Z-values are presented in parentheses. Baseline probability shows the baseline for marginal effects after ologit y = Pr for every outcome. Baseline pr. combined with the value given for a variable in each scale of companies' energy efficiency investments implemented out of total investments (%), indicates variable's increased impact on company's tendency to implement energy efficiency investments.
*** = 0.01 significance level, ** = 0.05 significance level, * = 0.1 significance level

	4	3	2	1	0
Variable	(over 10 %)	(5,1 - 10 %)	(1,1 - 5 %)	(0,1 - 1 %)	0 %
PB	0.12***	0.16**	0.15	-0.28**	-0.16
	(-2.77)	(-2.39)	(-0.66)	(-2.04)	(-0.77)
NPV	-0.10	-0.10	0.04	0.12	0.04
	(-1.62)	(-1.50)	(-1.08)	(1.33)	(1.03)
IRR	0.28***	0.17***	-0.18**	-0.21***	-0.06
	(2.69)	(2.91)	(-2.22)	(-2.87)	(-1.64)
PI	-0.06	-0.06	0.02	0.07	0.02
	(-0.95)	(-0.84)	(0.98)	(0.73)	(0.64)
Baseline pr.	0.13	0.20	0.49	0.14	0.03

Table 5.a shows significant positive correlation between the companies using IRR for investment evaluation and the relative amount that they are investing on energy efficiency. Even though marginal effects are significant for PB in Table 5.a, the payback period was not significant in the ologit regression (Table 5), so they cannot be kept as a reliable result from statistical analysis.

Variables were processed further in order to study more about the causal relationship involved in the density of investment making. As explained in the methodology section, payback period was kept alone as a conventional investment appraisal method, whereas NPV, IRR and PI formed a variable of *sophisticated investment appraisal methods* and Technology roadmapping and Value chain/Strategic cost management analysis formed a variable *strategic investment appraisal methods.*

Table 6. This table reports ordered logit regressions coefficients and their z-values. The sample includes survey questionnaire responses from 107 Finnish industrial companies related to their energy efficiency investment decision making. Dependent variable is an indicator for the partial amount of energy efficiency investments from company's total investments. Dependent variable is a likert scale measure (4: over 10 %, 3: 5,1 - 10 %, 2: 1,1 - 5 %, 1: 0,1 - 1 % and 0: 0 % of total investments) and independent variables are dummy variables (1: Yes, 0: No). McFadden's R^2 is selected for to show the adjustment effect in Pseudo R^2.
*** = 0.01 significance level, ** = 0.05 significance level, * = 0.1 significance level

	Model 1	**Model 2**
Payback period	-0.20	0.95
	(-0.12)	(0.80)
Sophisticated appraisal methods	1.85*	0.95**
	(1.72)	(2.15)
Strategic appraisal methods	-1.75*	
	(-1.83)	
N	41	76
Pseudo R^2	0.044	0.023

The findings presented in Table 6 indicate that companies that are using one or more of the sophisticated financial investment appraisal methods have implemented relatively more energy efficiency investments than other Finnish industrial companies. Interviewed were not able to distinct why the company has chosen to use these methods and what the benefits for using them are. The most common answer was that the management team, or some other person above them in the hierarchy, had demanded the use of more sophisticated methods in investment decision-making, and thus the employees used them diligently. Model 2 can be seen to be the more reliable of these two, because the sample size is significantly larger. Examination of strategic investment appraisal methods did not give any significant results to support their role in energy efficiency decision-making.

Table 6.a This table presents the marginal effects between the likert scale values of the original ordered logit regression for Model 2 (Table 6). Z-values are presented in parentheses. Baseline probability shows the baseline for marginal effects after ologit y = Pr for every outcome. Baseline pr. combined with the value given for a variable in each scale of companies' energy efficiency investments implemented out of total investments (%), indicates variable's increased impact on company's tendency to implement energy efficiency investments.
*** = 0.01 significance level, ** = 0.05 significance level, * = 0.1 significance level

Variable	4 (over 10 %)	3 (5,1 - 10 %)	2 (1,1 - 5 %)	1 (0,1 - 1 %)	0 0 %
Payback period	0.09	0.09	0.004	-0.13	-0.05
	(1.14)	(0.89)	(0.04)	(-0.73)	(-0.54)
Sophisticated appraisal methods	0.12**	0.09*	-0.07	-0.11**	-0.03
	(2.02)	(1.95)	(-1.50)	(-2.03)	(-1.45)
Baseline pr.	0.15	0.20	0.46	0.15	0.04

Few of the interviews revealed that some of the major energy efficiency investors have actually comprehensive evaluation scorecards as tools for investment decision-making:

> *"It is required in our company's investment decision-making guidelines. We are using kind of a scorecard, which has a verbal part, where to write the attributes, and then there is the calculations supporting the aggregate, which you have to be able to justify even though only the end numbers will be visible in the front page of the investment card. – One of the non-financial parts that have to cover is of course the environment. Especially, when the question is about an energy efficiency investment, the energy and emissions are taken into account."*

> *"In the end, it is according to the situation, which parts (of the scorecard) are emphasized the most. When we look at investments over 100 000 euros, there is always more explicated parts, whereas with 10 000 euro investments, it is enough to explain only the energy savings or gains from productivity improvements that investment yields."*

The more comprehensive, 'scorecard' way to evaluate energy efficiency investments could be favourable in the perspective of diminishing the energy efficiency paradox and thus getting companies to make more energy efficiency investments. The found results support the view that more sophisticated investment appraisal methods would provide more equal evaluation for energy efficiency investments, thus decreasing the unnecessary rejections of profitable energy efficiency investment opportunities.

4.2 The role of experts in energy efficiency investment decisions

Survey results shown in Table 7 indicate that the planning stage of the energy efficiency investment among companies involves mostly technical experts (82,7 %). Over half of the companies also involve an energy efficiency representative (54,8 %) and/or a management group (51,9 %) to participate in the planning stage of the investment. As indicated in chapter 2.3, the planning stage may have a much more important role for the final decision-making than is generally expected because the decision can actually be made already during the planning of the investment (Bower, 1970). However, only one third (34,6 %) employs a financial expert to the investment process already in the planning stage of an investment, even though the financial criteria were perceived clearly the most crucial factors in deciding whether an investment would be implemented or not (Table 2).

Table 7. Question concerning the people involved in the planning stage. (Appendix 3.)

Which of the persons/parties are actively involved in planning of the energy efficiency investment

Respondents: 104

	%	N*
Technical expert	82.7 %	86
Financial expert (e.g. CFO)	34.6 %	36
Energy efficiency responsible	54.8 %	57
Management group	51.9 %	54
Someone else, who?	9.6 %	10
I don't know	2.9 %	3

*of the respondents

As seen in Table 8, statistically significant findings suggests that when a financial expert is part of the investment process already in the planning stage, the company is more likely to implement energy efficiency investments. The marginal effects are showed from Model 3, because dropping the variables gave more significance for the results as seen when looking at the Pseudo R^2. Table 8.a shows that when company's relative amount of energy efficiency investments implemented increases, so does the tendency that company is employing financial expert (e.g. CFO) already to the planning stage of the investment process.

Table 8. This table reports ordered logit regressions coefficients and their z-values. The sample includes survey questionnaire responses from 107 Finnish industrial companies related to their energy efficiency investment decision making. Dependent variable is an indicator for the partial amount of energy efficiency investments from company's total investments. Dependent variable is a likert scale measure (4: over 10 %, 3: 5,1 - 10 %, 2: 1,1 - 5 %, 1: 0,1 - 1 % and 0: 0 % of total investments) and independent variables are dummy variables (1: Yes, 0: No). McFadden's R^2 is selected for to show the adjustment effect in Pseudo R^2.
*** = 0.01 significance level, ** = 0.05 significance level, * = 0.1 significance level

	Model 1	**Model 2**	**Model 3**	**Model 4**
PLANNING				
Technical expert	0.88	0.97	0.45	
	(0.93)	(1.09)	(0.55)	
Financial expert (e.g. CFO)	1.00	1.05	1.31**	1.24**
	(1.52)	(1.61)	(2.12)	(2.23)
Energy efficiency responsible	0.24			
	(0.29)			
Management group	0.81	0.73		
	(0.99)	(0.93)		
DECISION MAKING				
Technical expert	0.35	0.16	0.24	
	(0.38)	(0.21)	(0.33)	
Financial expert (e.g. CFO)	-0.51	-0.54	-0.59	-0.46
	(-0.93)	(-0.99)	(-1.10)	(-0.95)
Energy efficiency responsible	-0.37			
	(-0.46)			
Management group	-0.42	-0.41		
	(-1.32)	(-1.29)		
N	75	75	75	76
Pseudo R^2	0.038	0.037	0.027	0.024

Table 8.a This table presents the marginal effects between the likert scale values of the original ordered logit regression for Model 3 (Table 8). Z-values are presented in parentheses. Baseline probability shows the baseline for marginal effects after ologit y = Pr for every outcome. Baseline pr. combined with the value given for a variable in each scale of companies' energy efficiency investments implemented out of total investments (%), indicates variable's increased impact on company's tendency to implement energy efficiency investments.
*** = 0.01 significance level, ** = 0.05 significance level, * = 0.1 significance level

Variable	4 (over 10 %)	3 (5,1 - 10 %)	2 (1,1 - 5 %)	1 (0,1 - 1 %)	0 0 %
PLANNING					
Technical expert	0.05	0.04	-0.02	-0.06	-0.19
	(0.62)	(0.56)	(-0.84)	(-0.52)	(-0.46)
Financial expert (e.g. CFO)	0.21*	0.10**	-0.15	-0.13	-0.03
	(1.75)	(2.28)	(-1.56)	(-2.32)	(-1.58)
DECISION MAKING					
Technical expert	0.03	0.02	-0.01	-0.03	-0.01
	(0.35)	(0.33)	(-0.41)	(-0.32)	(-0.31)
Financial expert (e.g. CFO)	-0.07	-0.06	0.03	0.07	0.02
	(-1.14)	(-1.08)	(1.02)	(1.03)	(0.90)
Baseline pr.	0.15	0.19	0.48	0.16	0.04

The management group's (74 %) involvement increases as the investment process proceeds to the investment decision-making stage. The role of the financial experts (36,5 %) is still somewhat disregarded as mainly technical experts (74 %), management groups (74 %) and partly energy efficiency representatives (44,2 %) are the ones making the decision whether or not to implement an energy efficiency investment in Finnish industrial companies.

Consequently, survey results gave evidence that the early involvement of financial expert correlates positively with company's tendency to implement energy efficiency investments (Table 8/8.a). The reason for this correlation was investigated in the follow-up interviews. Almost all of the interviewed explained the cause and effect as a credibility issue:

> *"Yes, the involvement of a financial professional increases the possibility that the investment will become implemented. I think that the financial figures are the key, and also the way that the opportunity is presented is much more professional. In a way, the credibility of the evaluation is in a higher level when the data is put forward and people know who have been there preparing the investment evaluation."*

"When financial expert is already involved in the planning process, there is a greater probability that the calculations are correct. It is a credibility matter."

A serious credibility issue can arise due to the figures and other justification behind the investment, especially when financial criteria are valued higher than others in the investment decision-making process (Table 2). The way the investment is presented and justified, as well as the person behind the figures, can thus have a significant effect on whether the decision-makers become convinced of the profitability of the investment opportunity. These findings support the view that people involved already in the preparation stage of an investment may have a significant influence on what investment opportunity will eventually be selected, thus switching the weight from the evaluated criteria to the questions *how* and *who* have done these evaluations.

According to the interviews, financial experts involved in the investment process are usually from within the company from the finance department, however, an outside consultant and the auditor of the company, were also used as reinforcement in the planning stage. The decreasing amount of errors and the comprehensive, long-term view given were seen to speak in favor of having the financial expert already involved from the beginning of the investment process, as evidenced in these interview comments:

"It also increases the probability that the investment will become profitable and implementable, and also the probability of calculation errors is smaller."

"Yes, the financial expert has a really important role in the process. The financial expert takes actively into account the profitability of the investment and can realize the current stage of the company."

"I'm not a financial expert. I don't have the competency either, so financial expert brings the required competency and the financial perspective into the process."

Some of the respondents indicated that because the financial expert has been involved in the investment planning stages, more sophisticated investment appraisal methods have been adopted and the investment is evaluated more comprehensively.

"Because the financial expert has been involved in the investment process, more sophisticated investment appraisal methods are applied, investment is evaluated more broadly and the use of rule-of-thumb is decreased."

In addition to the more comprehensive evaluation of investment's costs and benefits and the increased credibility and the accuracy of calculations in the mind of a final decision-maker, other explanatory factors why an energy efficiency investments are implemented relatively more by teams with financial expert involved in the planning stage can be for example more versatile know-how or better cooperation and knowledge sharing of different experts. The findings of this study appear to contradict those of Lumijärvi's (1991) when it comes to the economic arguments' actual power to justify an investment opportunity for implementation. However, according to this study, the power depends on the credibility of the person proposing the investment opportunity and financial experts are seen to command this integrity.

5. Conclusion

This study examines the decision-making in Finnish industrial companies with regard to energy efficiency investments. It aims to identify factors that hinder the implementation of energy efficiency investments in industrial sector. The investment appraisal methods and the investment process participants influencing the investment decision-making were especially in focus.

Financial criteria dominate the evaluation of investment opportunities. This further highlights the role of the financial investment appraisal methods used in the company. The findings of the study showed that the payback criterion is the most common investment appraisal method used in 93 % of the Finnish industrial companies following with IRR (39 %) and NPV (29 %). Few companies actually use strategic investment tools in practice. The payback method is said to be an inadequate measure for energy efficiency investments, because it neither takes into account the time value of money nor the future cash flows or strategic implications of the investment. Energy efficiency investments' profits are claimed to capitalize in a longer term and they might also have strategic implications. In regard to the use of payback criterion, findings also indicate a discrepancy. According to the survey, companies have set their energy efficiency objectives in 4 to 7 year scale whereas the median for energy efficiency investments' payback criteria was only 1 to 2 years. Even though it seems that companies tend to understand that energy efficiency objectives are not acquired in the short-term, the longer term opportunities are usually disregarded. This also supports the assumption that payback criterion would be an inadequate investment appraisal method in the energy efficiency investment point of view and companies should adopt different views for investment evaluation in order to equalize their appraisal patterns.

Results indicate that companies that are using sophisticated financial investment appraisal methods and more specifically IRR when evaluating energy efficiency investments go on to implement more energy efficiency investments than other Finnish industrial companies. This study also suggests that having a financial expert involved in the investment process already from the planning stage increases the likelihood that energy efficiency investment will be approved in the decision-making stage. The follow-up interviews suggested that the potential reason for this phenomenon is the increased credibility surrounding the investment opportunity in the eyes of the final decision-makers. In addition, some of the respondents indicated that the financial expert's involvement has affected the investment process by increasing the use of sophisticated financial investment evaluation methods and also broadening the scope of the evaluation from quantitative to qualitative factors.

The intention was not to make a normative study, however, the correlations found from the analysis can be further used as a tool to form normative suggestions for industrial companies wanting to ensure that all the profitable investment possibilities will get an equal treatment. This can be achieved with managerial implications: by adopting the use of more sophisticated financial investment evaluation methods, especially IRR, and ensuring that a versatile team with financial expert included, is already involved in the planning stage of the investment process. Companies might not be only rejecting profitable investment opportunities when evaluating them with simplistic methods such as payback, but also disregarding the environmental and social benefits related to participating in the common goal of decreasing the energy resource consumption.

The results of this study are intriguing and thus pave the way for further research into the causal relations between investment decision-making processes and the actual implementation of energy efficiency investments. Further studies could concentrate on generalizing these findings with larger data, including industry dummies, and on exploring deeper how these scorecards discovered in the interviews are created, used and affecting the investment decision-making processes in different kind of companies. There may be a need to distinguish the nature of the businesses and thus explain better which kind of companies and what businesses make energy efficiency investments as well as which kind of practices they are exploiting. In addition, the investment process behind the guidelines and appraisal methods may still consist of various undefined factors that can reveal surprising causals for energy efficiency appraisal, as was discovered with the new finding of the role of the financial expert's involvement in the investment process.

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Appendices

Appendix 1. **Descriptive statistics of the companies involved in the survey**. The sample includes survey questionnaire responses from 107 Finnish industrial companies about their customs related to investment processes, their investment appraisal patterns and the tendency to implement energy efficiency investments.

All companies in 2009	**Min**	**Max**	**Mean**	**Median**	**Std. Dev.**
Net sales (m€)	6.59	9 663.00	1 579.73	300.00	2 487.30
Personnel size	13	27390	4883	1042	7108
ROE	-232 %	107 %	-10 %	6 %	94 %
ROI / ROCE	-163 %	90 %	0 %	6 %	42 %

Appendix 2. **Panel specific descriptive statistics**. Small and medium sized companies, net sales (NS) under 50 m€, were examined as an own group (20 companies) whereas the big companies were divided into three: 50 m€ ≤ NS < 1000 m€ (28), 1000 m€ ≤ NS < 5000 m€ (25) and over 5000 m€ (9). Company's profitability in 2009 was examined by using return on equity (ROE). Different categories are following: ROE below 0 % (27 companies), 0 ≤ ROE < 10 % (25), 10 % ≤ ROE < 50 % (23) and 50 % or more (6). Some companies answered to the survey anonymously. Therefore their net sales and profitability were not able to be tracked and thus that data is not included in the descriptive statistics.

Panel A. Companies by Net Sales in 2009

	Energy efficiency investments made in 2009 from total investments				
Net Sales	over 10 %	5,1 - 10 %	1,1 - 5 %	0,1 - 1 %	0 %
under 50 m€	17 %	22 %	50 %	0 %	11 %
50 m€ ≤ x < 1000 m€	8 %	24 %	48 %	16 %	4 %
1000 m€ ≤ x < 5000 m€	14 %	0 %	45 %	23 %	18 %
5000 m€ or over	0 %	50 %	25 %	25 %	0 %

	Investment evaluation methods used for evaluating energy efficiency investments			
Net Sales	Payback period (PB)	Net present value (NPV)	Internal rate of return (IRR)	Profitability Index (PI)
under 50 m€	95 %	35 %	45 %	5 %
50 m€ ≤ x < 1000 m€	96 %	14 %	36 %	11 %
1000 m€ ≤ x < 5000 m€	92 %	36 %	36 %	16 %
5000 m€ or over	67 %	33 %	67 %	11 %

	Investment evaluation methods used for evaluating energy efficiency investments			
Net Sales	Value chain/ Strategic cost management analysis	Technology roadmapping	Sophisticated appraisal methods	Strategic appraisal methods
under 50 m€	20 %	35 %	50 %	35 %
50 m€ ≤ x < 1000 m€	18 %	39 %	39 %	39 %
1000 m€ ≤ x < 5000 m€	24 %	36 %	48 %	36 %
5000 m€ or over	44 %	56 %	67 %	56 %

	Experts involved in the planning stage of the investment process			
Net Sales	Technical expert	Financial expert (e.g. CFO)	Energy efficiency responsible	Management group
under 50 m€	80 %	15 %	50 %	15 %
50 m€ ≤ x < 1000 m€	89 %	21 %	32 %	4 %
1000 m€ ≤ x < 5000 m€	84 %	36 %	64 %	24 %
5000 m€ or over	78 %	33 %	100 %	22 %

	Experts involved in the final decision making stage			
Net Sales	Technical expert	Financial expert (e.g. CFO)	Energy efficiency responsible	Management group
under 50 m€	70 %	45 %	40 %	80 %
50 m€ ≤ x < 1000 m€	79 %	36 %	29 %	75 %
1000 m€ ≤ x < 5000 m€	80 %	52 %	56 %	68 %
5000 m€ or over	56 %	44 %	56 %	67 %

Panel B. Companies by Profitability in 2009

	Energy efficiency investments made in 2009 from total investments				
ROE	over 10 %	5,1 - 10 %	1,1 - 5 %	0,1 - 1 %	0 %
below 0 %	16 %	16 %	40 %	12 %	16 %
0 ≤ x < 10 %	5 %	18 %	45 %	18 %	14 %
10 % ≤ x < 50 %	10 %	20 %	50 %	20 %	0 %
50 % or more	20 %	20 %	60 %	0 %	0 %

	Investment evaluation methods used for evaluating energy efficiency investments			
ROE	Payback period (PB)	Net present value (NPV)	Internal rate of return (IRR)	Profitability Index (PI)
below 0 %	93 %	22 %	41 %	7 %
0 ≤ x < 10 %	92 %	44 %	44 %	20 %
10 % ≤ x < 50 %	87 %	22 %	48 %	4 %
50 % or more	100 %	17 %	17 %	17 %

	Investment evaluation methods used for evaluating energy efficiency investments			
ROE	Value chain/ Strategic cost management analysis	Technology roadmapping	Sophisticated appraisal methods	Strategic appraisal methods
below 0 %	19 %	30 %	41 %	30 %
0 ≤ x < 10 %	40 %	56 %	60 %	56 %
10 % ≤ x < 50 %	9 %	30 %	48 %	30 %
50 % or more	33 %	50 %	33 %	50 %

	Experts involved in the planning stage of the investment process			
ROE	Technical expert	Financial expert (e.g. CFO)	Energy efficiency responsible	Management group
below 0 %	85 %	37 %	59 %	15 %
0 ≤ x < 10 %	84 %	20 %	52 %	12 %
10 % ≤ x < 50 %	78 %	26 %	61 %	22 %
50 % or more	100 %	0 %	17 %	0 %

	Experts involved in the final decision making stage			
ROE	Technical expert	Financial expert (e.g. CFO)	Energy efficiency responsible	Management group
below 0 %	78 %	63 %	44 %	78 %
0 ≤ x < 10 %	72 %	40 %	40 %	64 %
10 % ≤ x < 50 %	65 %	30 %	48 %	87 %
50 % or more	100 %	17 %	33 %	33 %

Appendix 3. The survey questionnaire. The survey questionnaire included the following questions. Questions were created based on previous research of capital investment practices, the created investment process description and expert discussions with employees from Motiva Oy and Aalto University (Figure 1). Some of the questions required the respondents to evaluate the question on a scale 1 to 5 (5=Totally agree, 1=Totally disagree) and some of them have multiple choices to select. The below presented questions are translations from the original Finnish ones.

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1. I am involved in the preparation, implementation (etc.) of the energy efficiency investments
2. My background is…
3. How much did the company/subsidiary you are working for spent on investments in general in 2009?
4. How big part of these investments were energy efficiency investments (%)?
5. Arrange following reasons to prioritized order why the company you are working for have implemented energy efficiency investments in the past
6. I think that people have been very pleased for the energy efficiency investments that our company has implemented.
7. Why do you think that energy efficiency investments have been rejected in the past? Select one or more of the most important reasons.
8. The company that I am working for has an intention to implement more energy efficiency investments than it has in the past.
9. The subventions that the Ministry of employment and the economy is providing, have a big influence on whether an energy efficiency investment will be accepted.
10. Select one of the following that describes the company you are working for the best

    10.1 Company operates in a dynamic and growing industry.
    Company operates in a stable market that has moderate growth potential.

    10.2 Company aims to be a pioneer in the industry. Company's competitiveness is especially based on product development, marketing and understanding our customers' needs.
    Company aims to add value for its clients. Company's competitiveness is especially based on efficiency and ability to provide our products and services with competitive prices.

    10.3 Company's performance (financial profit and market position) is good or even excellent compared to the stakeholders' expectations.
    Company's performance (financial profit and market position) does not achieve stakeholders' expectations.

11. What is the time scale that the company yuo are working for have identified its energy efficiency targets?
12. Energy efficiency investments are a significant strategic competitive factor to the company that I am working for.
13. Energy efficiency investments are strategically more important for the company that I am working for than production/operational investments.
14. Energy efficiency targets that the company that I am working for has set to itself, are communicated to all organizational levels.
15. Are the energy efficiency advancements regarded in your company's reward system?

16. The company I am working for has separated a part from the yearly budget for energy efficiency improvements.

17. Select one of the following that describes the best of the working methods that the company that you are working for is obeying.

    Our investment budget guides operations precisely, and if the targets are not met, sanctions will occur (e.g. lost bonuses).
    There will not be any sanctions (e.g. lost bonuses) even though the budgeting targets are not met.
    Something else, what?

18. Our company seeks systematically new energy efficiency investment opportunities.

    Yes, we make energy inspection on a regular basis.
    Yes, we do have initiative system.
    Yes, we survey technological developments systematically.
    Yes, somehow else?
    No, we have too little time to focus on energy efficiency investments.
    No, why?
    I don't know.

19. Does the company you are working for follow its energy consumption?

    With absolute figures.
    With specific energy consumption measures (e.g. energy consumption per tonn of production).
    With an index figure (aka.related to some specific reference period).
    Somehow else, how?
    It does not follow.

20. Does the company you are working for always audit the changes in energy consumption after the energy efficiency investment has been implemented?

    Yes, on the whole production unit level.
    Yes, on the resort.
    Yes, occassionally.
    Yes, some other way, how?
    No, we do not follow. We rely on the calculations.
    No, we do not follow in any way.
    No, some other reason why?

21. If the company you are working for audits the changes in energy consumption, the found results are exploited for…

    … to improve conduct systems (e.g. ISO 14001 and EMAS)
    … to improve guidelines, such as investment, planning and purchase guidelines
    … some other way, how?
    We do not exploit them.
    I don't know.

22. How does your company search opportunities available in the market?

    by keeping regularily contact with the suppliers.
    by participating in to training events and seminars.
    by cooperating with other operators in the industry.
    by searching information for example from the Internet.
    by exploiting different industry publications and web pages.
    by following related research and development projects in Finland and in abroad.
    Somehow else, how?
    We do not search opportunities.
    I don't know.

23. In my opinion, companies need purchasing guidelines that take into account energy efficiency aspects.

24. Companies need purchasing guoidelines that take into account energy efficiency especially for..

    ..equipment purchases.
    ..system purchases.
    ..process purchases.
    ..service purchases.
    ..somewhere else, where?
    I don't think that they are needed.

25. Does the company you are working for have investment/ purchase process descriptions for to guide performance in different units?

    Yes, and energy efficiency is also taken into account in them.
    Yes, but energy efficiency is only taken into account in some of the investment types.
    Yes, but energy efficiency is not taken into account.
    Company does not have them.
    I don't know.

26. Which of the persons/parties are actively involved in planning of the energy efficiency investment?

    Technical expert
    Financial expert (e.g. CFO)
    Energy efficiency responsible
    Management group
    Someone else, who?
    I don't know.

27. Which of the persons/parties are actively involved in making the final decision whether an energy efficiency investment will be accepted or rejected?

    Technical expert
    Financial expert (e.g. CFO)
    Energy efficiency responsible
    Management group
    Someone else, who?
    I don't know.

28. Based on your individual experience, evaluate the importance of the below mentioned criteria in investment decision making in the company you are working for.

    Financial criteria
    Material efficiency
    Process reliability
    Process quality
    Environmental criteria
    Energy efficiency criteria
    Safety criteria
    Reliability
    Technical risk

29. We evaluate investment opportuinities in general by using the following criteria
    1=1st priority, 2=2nd priority, 3rd priority, No=We don't evaluate/I don't know.

    Payback period (PB)
    Net present value (NPV)
    Internal rate of return (IRR)
    Profitability index (PI)

    Balanced scorecard
    Value chain / Strategic cost management analysis
    Technology roadmapping

30. We evaluate energy efficiency investment opportuinities by using the following criteria
    1=1st priority, 2=2nd priority, 3rd priority, No=We don't evaluate/I don't know.

    Payback period (PB)
    Net present value (NPV)
    Internal rate of return (IRR)
    Profitability index (PI)

    Balanced scorecard (BSC)
    Value chain / Strategic cost management analysis
    Technology roadmapping

31. Our payback criterion is..

    31.1 ..for investments in general
    31.2 ..for energy efficiency investments

32. Do you compare offers with anything else than based on price?

    Yes, based on life cylce costs.
    Yes, based on energy consumption or energy savings.
    Yes, based on decreased waste amounts.
    Yes, based on CO_2 emission levels.
    Yes, based on fuel consumption.
    Yes, based on something else, what?
    No, we base our evaluation solely on price.

33. Would you consider energy efficiency investments having more hidden risks than investments in general that are not necessarily visible already in the planning phase?

    Yes, energy efficiency investments may not necessarily be technically feasible.
    Yes, energy efficiency investments may not necessarily yield the calculated cost savings.
    Yes, some other reason, what?
    No, I wouldn't consider.

34. If you are involved in purchasing of services (e.g. maintenance outsourcing), do you give specific guidance for the service provider about your energy efficiency requirements?

    Yes, what?
    No.
    We don't purchase services.

35. How do you evaluate the successfulness of the investment after its implementation (the investment has been taken into use and started to yield cost savings or positive cash flows?

    By calculating whether the energy efficiency targets are met.
    By evaluating how well the investment project participants have succeeded.
    By comparing the budgeted profitability effects on the actual ones.
    By evaluating the overall successfulness of the investment process.
    Someway else, how?
    We don't evaluate.

Appendix 4. The list of interview questions. The interviews were conducted via phone during December 2010 among the survey questionnaire respondents that had indicated their availability for follow-up questions. Each of the seven interviews lasted for 8–12 min. Companies were selected in the basis of their answers, so that the big and small companies with different sized investment portfolios became represented. The interviews were semi-structured with a list of questions in order to facilitate consistency, however, interviewees were asked to discuss more about the findings that were most relevant regarding their survey questionnaire answers. The below presented questions are translations from the original Finnish ones.

Questions related to the investment evaluation methods

• Why do you think that the company you are working for is using IRR/NPV/PB etc. as an investment evaluation method for energy efficiency investments and investments in general?

• What benefits do you think that the method has as an investment evaluation method in general and/or for energy efficiency investments?

• Have the company you are working for set required return targets for energy efficiency investments and/or investments in general?

• What is the required return target and can it be different for different kind of investments (operative, energy efficiency, strategic etc.)?

• How big of an impact/role does the method have in the investment process and for the financial decision?

• Does the company you are working for use various methods in conjunction and do they have an equal weight in the appraisal?

• The survey questionnaire indicated that the company you are working for uses the Balanced Scorecard for evaluating energy efficiency investments. Could you elaborate how BSC is used for the described purpose?

• Why the company you are working use IRR method and not for example NPV?

• How do you calculate the required return target for NPV calculations?

• What is the payback time requirement for different kind of investment opportunities? Does it differ between them?

• Do you discount the predicted cashflows when calculating the payback period?

• Have you noticed that energy efficiency investments would tend to be rejected more often compared to operative ones because they do not meet the payback criterion?

• Do you take into account the strategic implications related to investment opportunities when evaluating them?

• If the company you are working for uses various evaluation methods, what is the weight between them?

• Does the company you are working for consider an energy efficiency options when making an operative investment decisions?

• Is the company you are working for flexible what comes to the financial targets?

• Are the investment evaluation principles same throughout the company's units?

Questions related to the involvement of financial expert in the investment process

• The survey questionnaire indicated that the company you are working for involves financial experts to the planning stage of the investment process, what is his/her role in the process?
• Do you feel that especially the involvement of the financial expert affects the investment process somehow?
• Do you think that the involvement increases the use of more sophisticated investment evaluation methods in the process?
• Is the financial expert, who is involved in the investment process, usually from inside the company or an external expert?
• Is the financial expert, who is involved in the investment process, also involved in the final decision making?